LBNE Photon Detector Testing at TallBo

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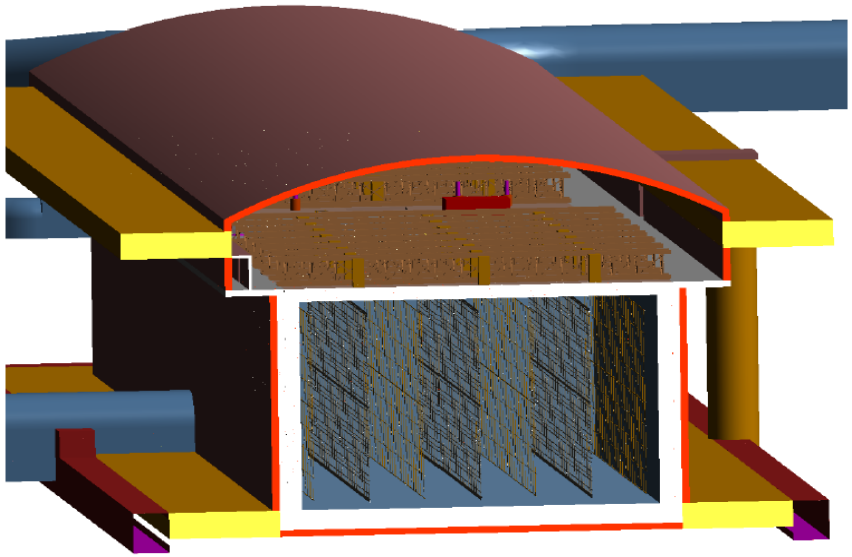
- Liquid Argon Time Projection Chambers
  - 120 Anode Plane Arrays suspended throughout liquid argon cryostat to create TPC cells



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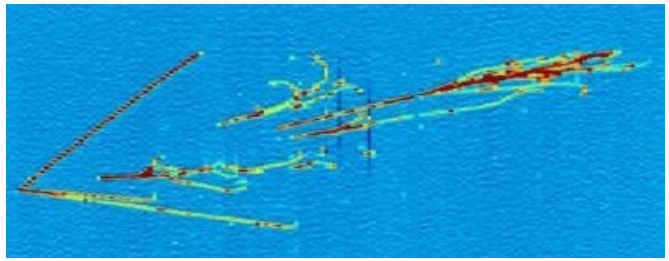
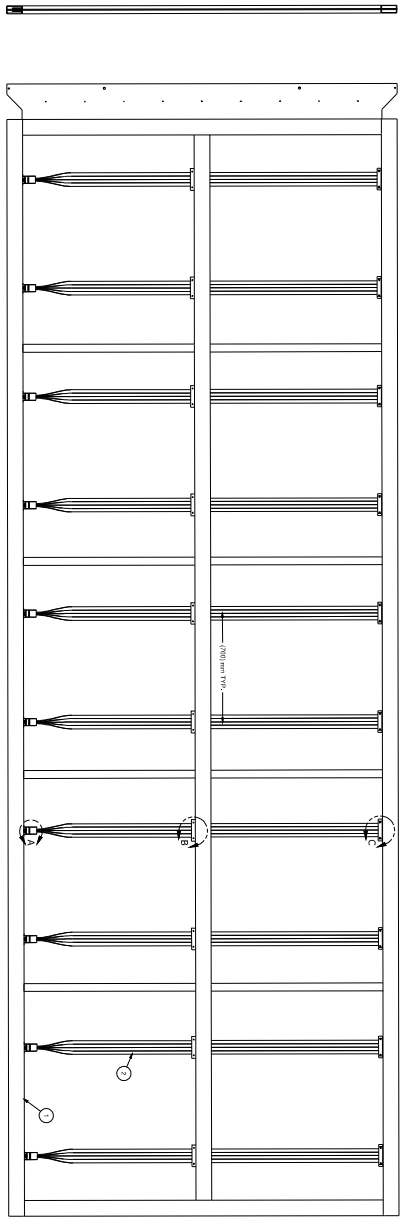
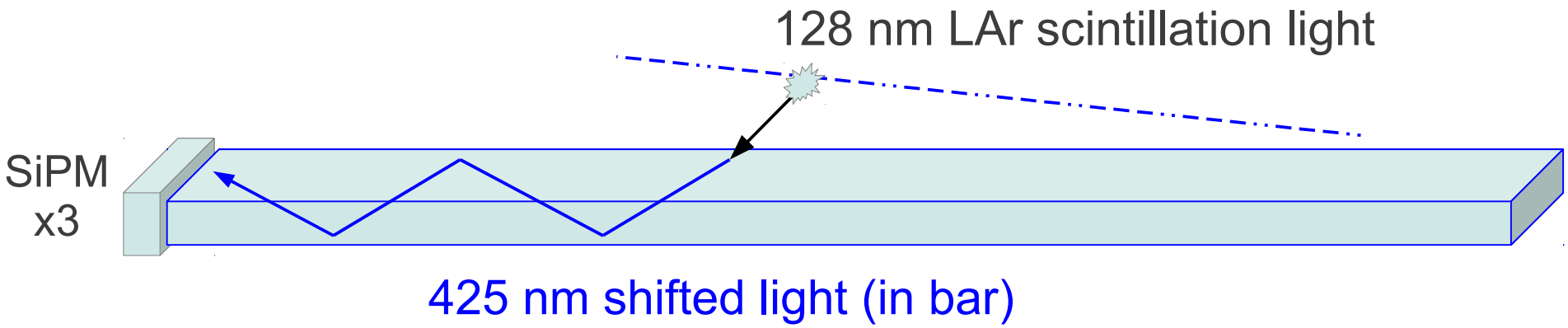




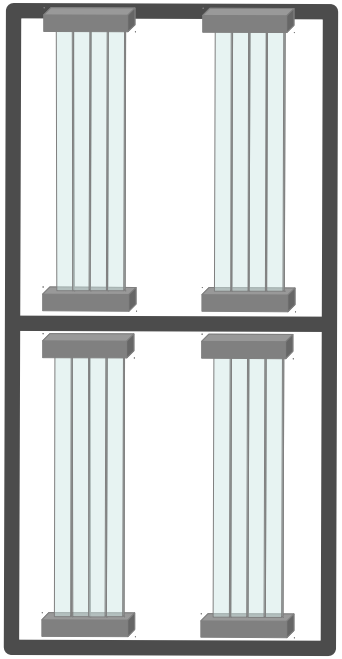
- Photon Detection for drift time calculation
  - Liquid argon scintillates at 128 nm
    - Prompt signal (few ns)
    - Slow signal (τ ~ 1.6 μs)
  - Photon detector paddles inserted into frame of Anode Plane Arrays inside TPC wires
    - 20 1-meter paddles per APA
  - Prompt signal from charged track gives t_0 for transverse position determination

- Acrylic bar spray-coated with wavelength shifting compound
  - 6 mm x 1 in x 20 in
    - 1 m long in FD, 4 per paddle
  - Wavelength shifter (WLS) melted into surface
    - Tetraphenyl butadiene (TPB) or
    - 1,4-bis-(o-methyl-styryl)-benzene (bis-MSB)
  - Comparing 10, 20, 35, & 50 coats



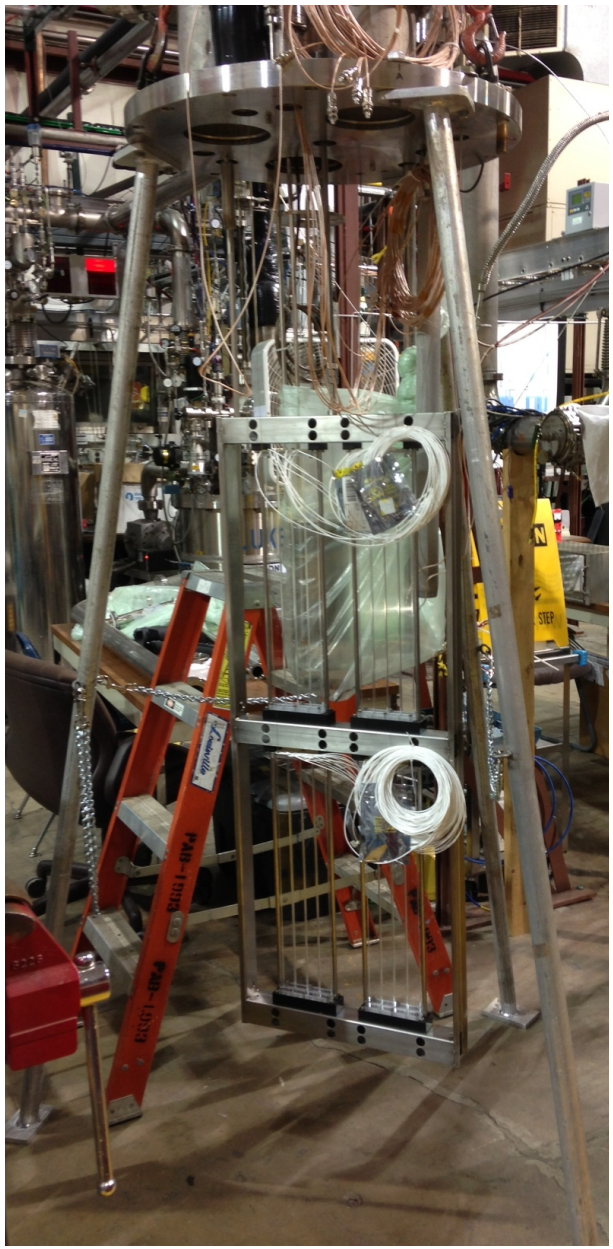
- 3 Silicon Photomultipliers (SiPM) read out end of bar
  - Strongly reverse-biased array of photodiodes
  - SensL MicroFB-60035-SMT
  - 6 mm x 6 mm active area (18960 microcells)
  - 24.5 V bias (gain of a few x10^6)
  - Signal into shaper/amplifier (gain ~200)

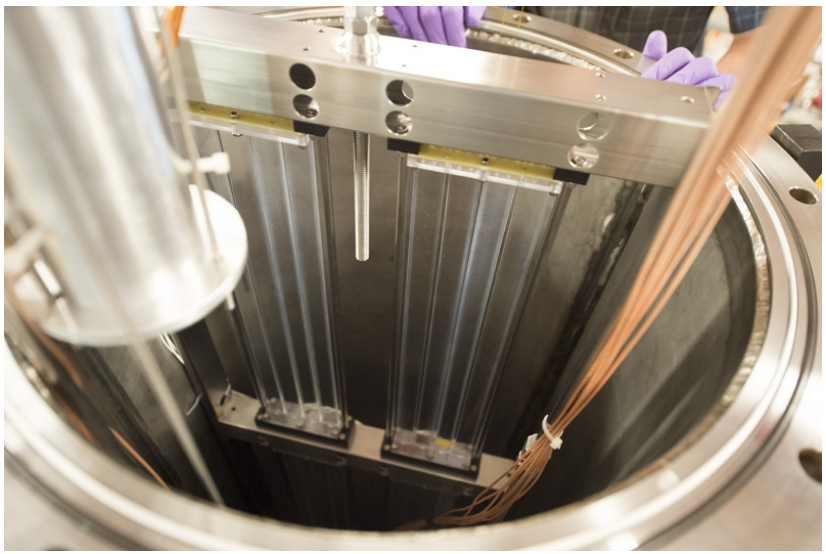
- New 84”-tall LAr dewar at Proton Assembly Building (PAB)
  - Interchangeable with existing 39” dewar “Bo”
- Space for 4 photon detector paddles
  - 16 bars
    - 14 from IU
    - 2 from MIT
  - 48 SiPMs
  - Mount and frames from CSU

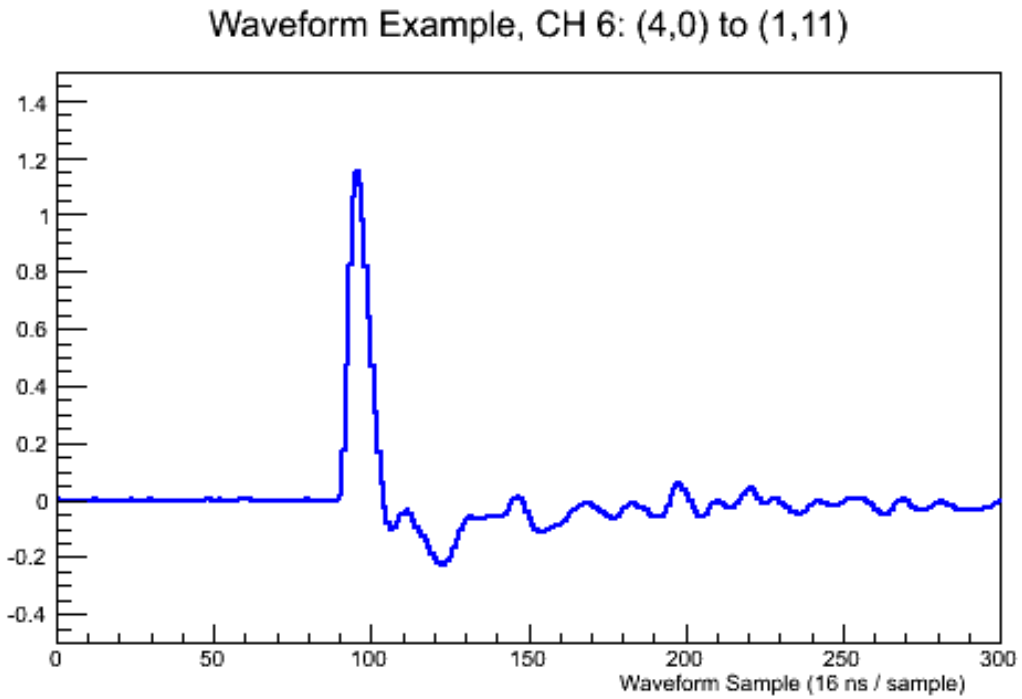


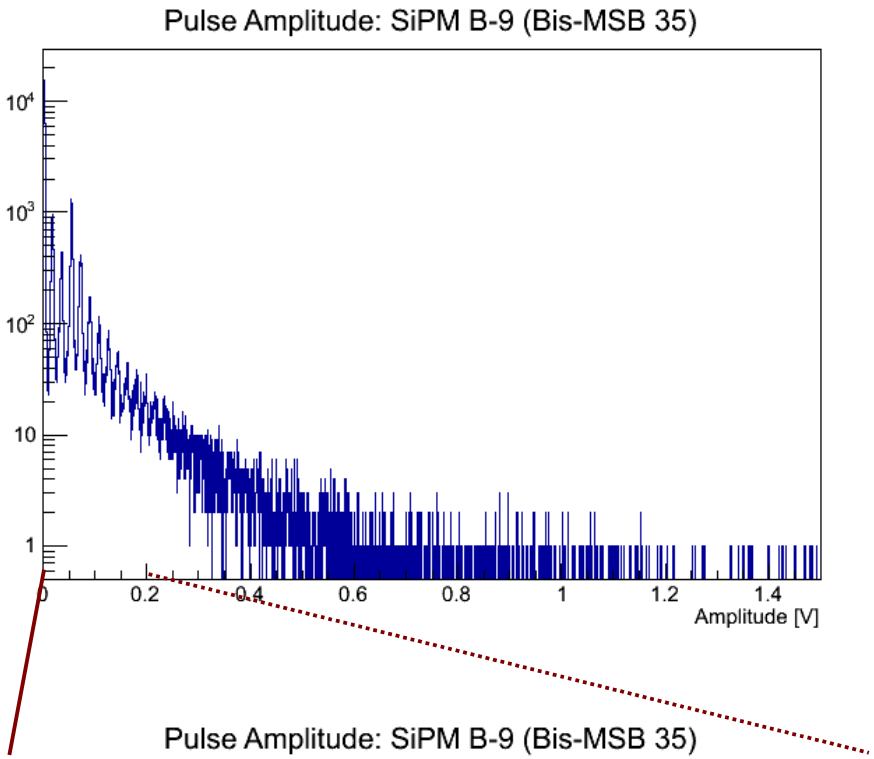
- Goals
  - Exercise readout of multiple bars/paddles
  - Study relative light yields from various waveshifter/coating combinations
  - Study scintillation detection from cosmics with a large variety of tracks through LAr volume

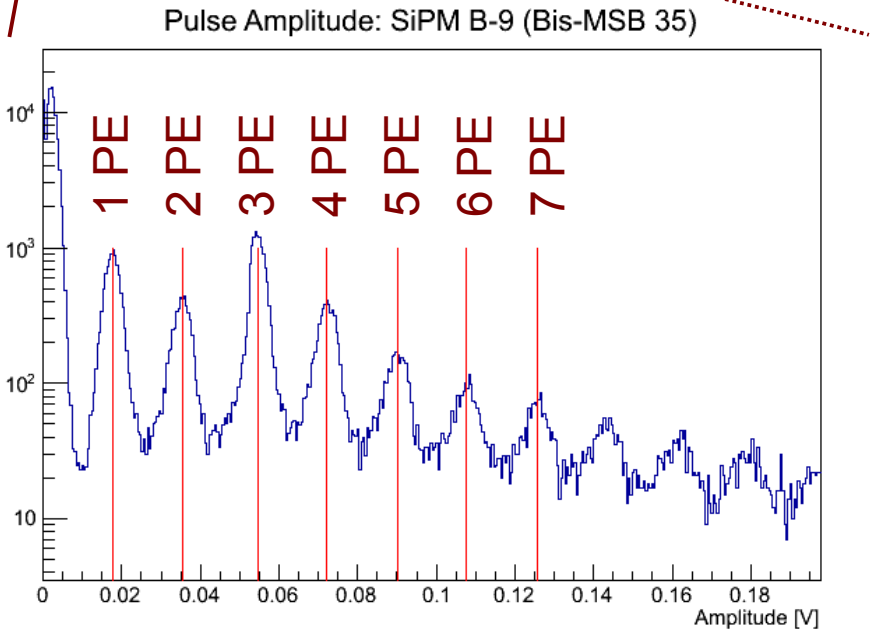
- Successful installation on October 11, LAr on October 16/17





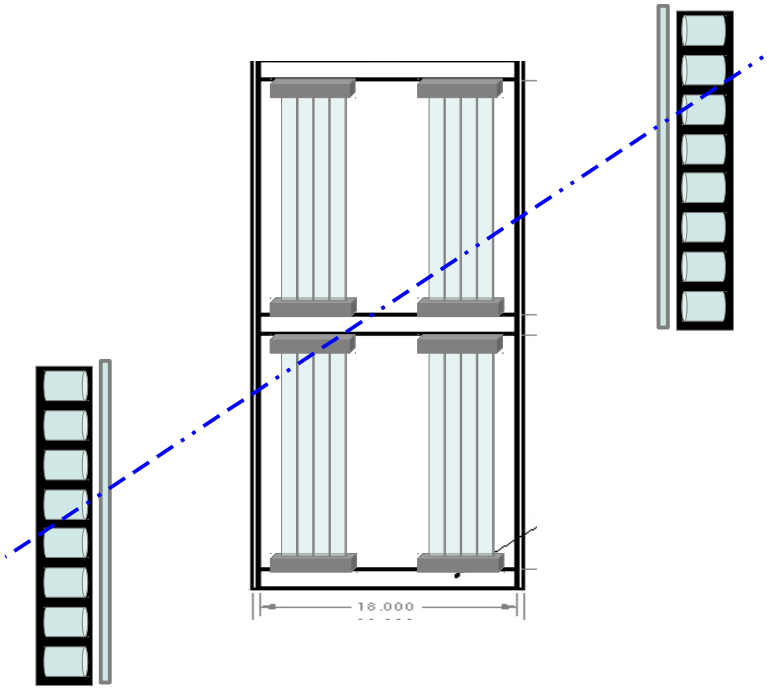






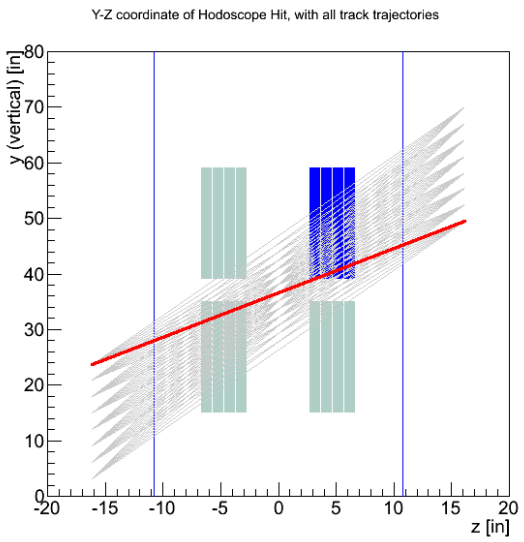
- Pulse heights fall into discrete values, corresponding to integer photoelectron signals
  - Calibrate based on simple peak search
- Post-pulse activity may be secondary scintillation signal
  - Analysis in the near future

- Two 8x8 Arrays of PMTs from CREST balloon-based cosmic ray experiment
  - Barium-fluoride crystals with TPB coating
  - Positioned on opposite sides of dewar (one elevated 48”)
- Plastic scintillator paddles
  - Gamma (Compton, etc.) veto
    - BaF_2 crystals sensitive to x-rays
- Shower vs single particle
- Approximate track reconstruction
- Four-fold coincidence trigger
  - >1 PMT on each array
  - One paddle on each side
  - ~2 Hz 4-fold trigger rate

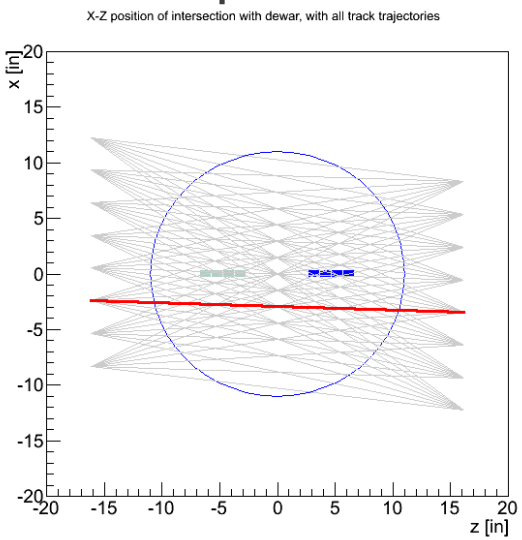


- Variety of track trajectories through hodoscope to study

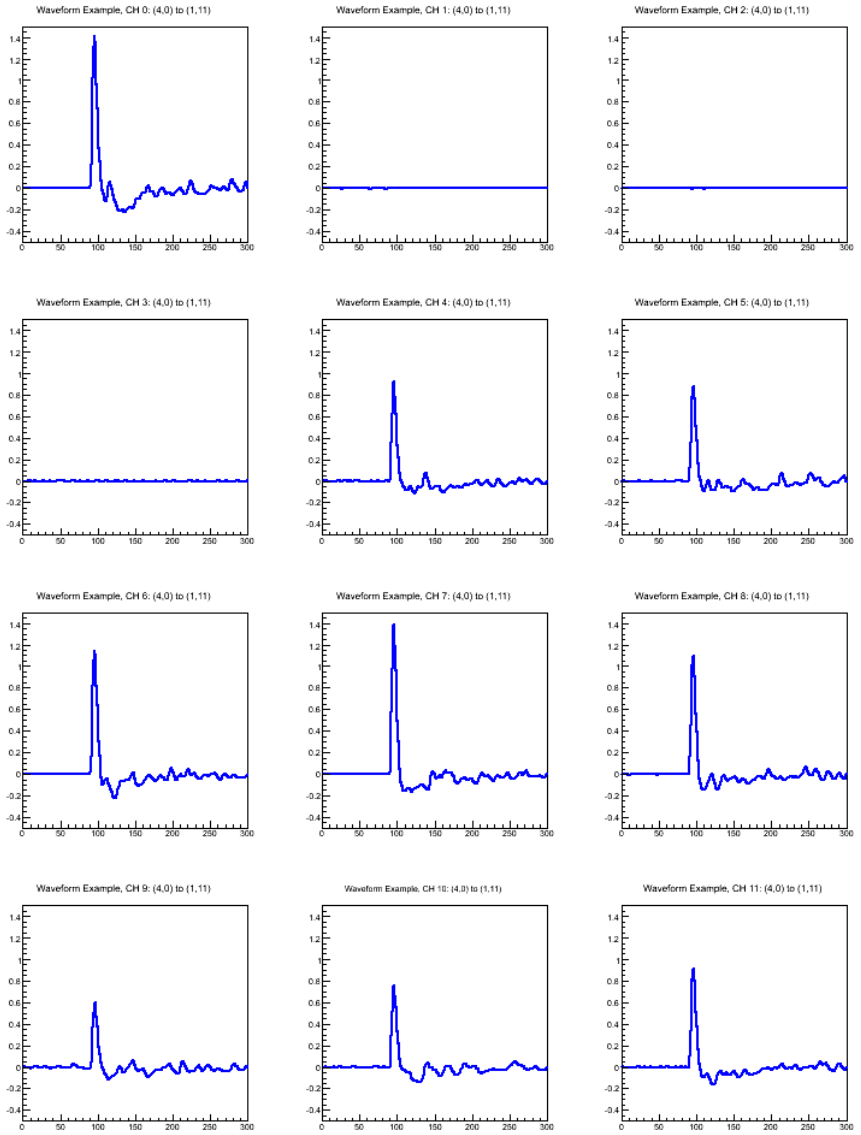
Side View



Top View



Example Track viewed by Paddle B



TPB-20

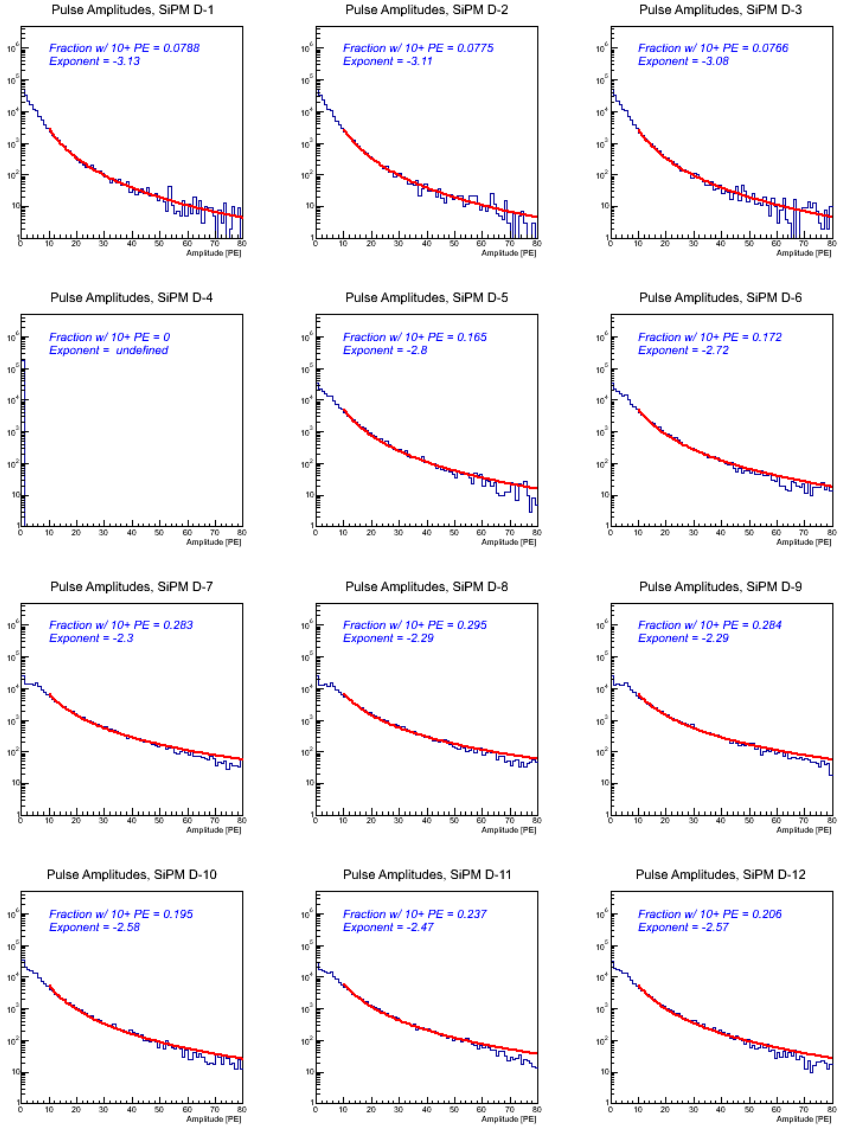
TPB-20

Bis-MSB 35

Bis-MSB 35

- "Free run" mode (self-triggered, OR of all SiPMs in a paddle)
  - Light from all cosmics through dewar
  - Look at distribution of calibrated signal amplitudes on each SiPM

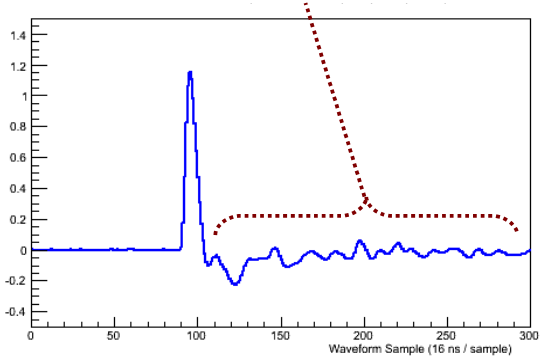
- Look for relative differences in light yield distributions
  - Preliminary results indicate *35 coats* is best choice for Bis-MSB
  - "Industrially"-produced IU bars not quite as good as hand-crafted "artisanal" MIT bars
    - Good enough?
    - Discovering room for improvement!

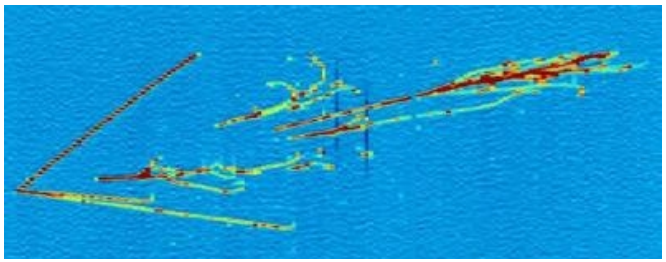


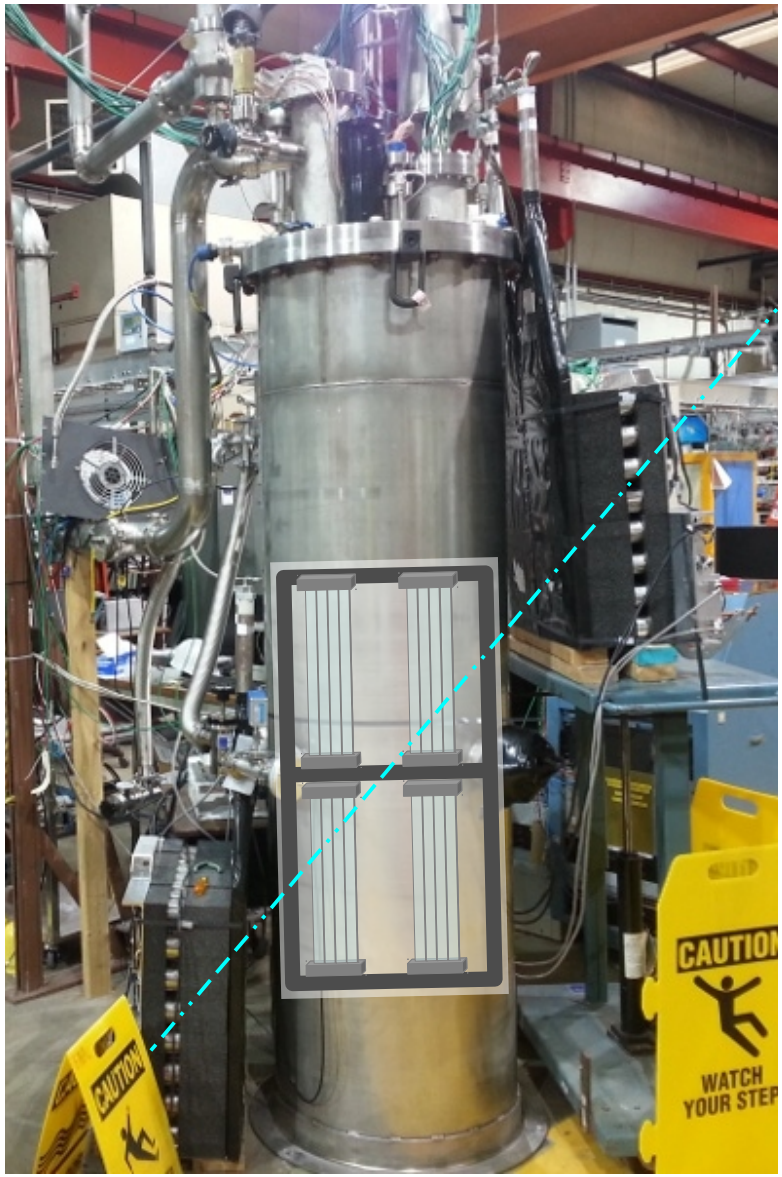
- LBNE Photon Detector prototype tests at TallBo underway and proceeding smoothly

- Data collection continuing this week
  - Muon telescope for cosmic triggers
  - Self-triggered “free run”
  - LEDs at dewar lid for cross checking
  - Plan to inject xenon to LAr Tues/Wed

- Preliminary analyses evolving, but already quite interesting
  - Bar-to-bar comparisons
  - Light yield vs track position (coming soon)
  - Late light studies on the horizon

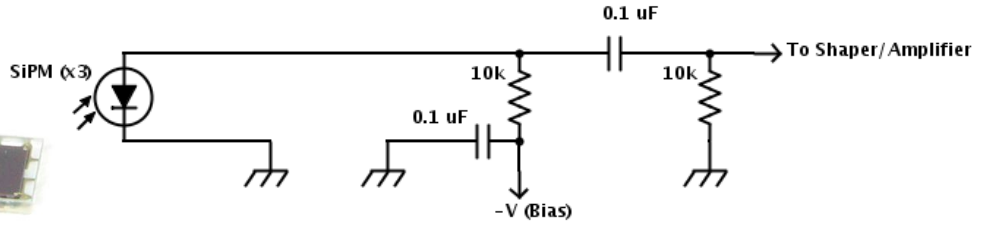




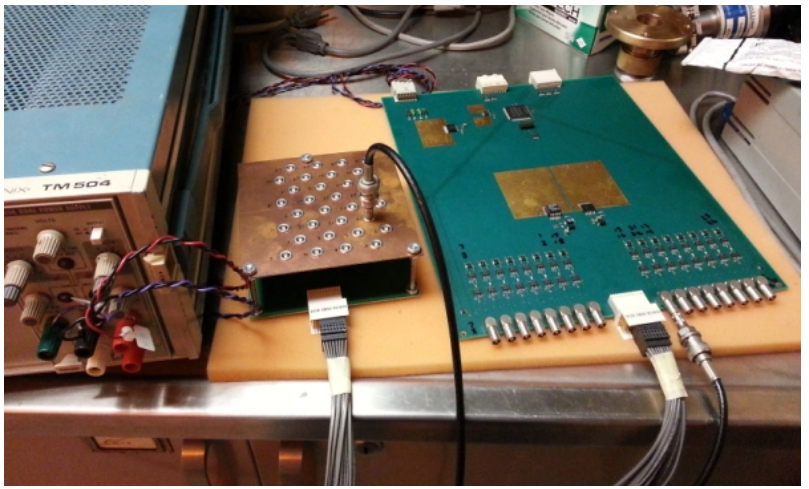


Backup

- Set of 3 independent SiPMs
  - SensL MicroFB-60035-SMT
  - 24.5 V bias

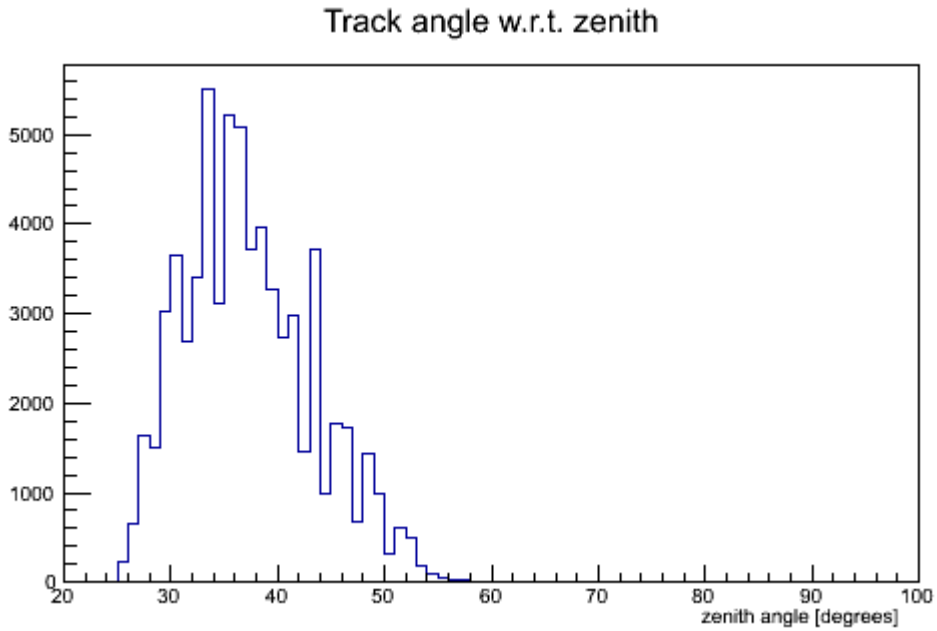


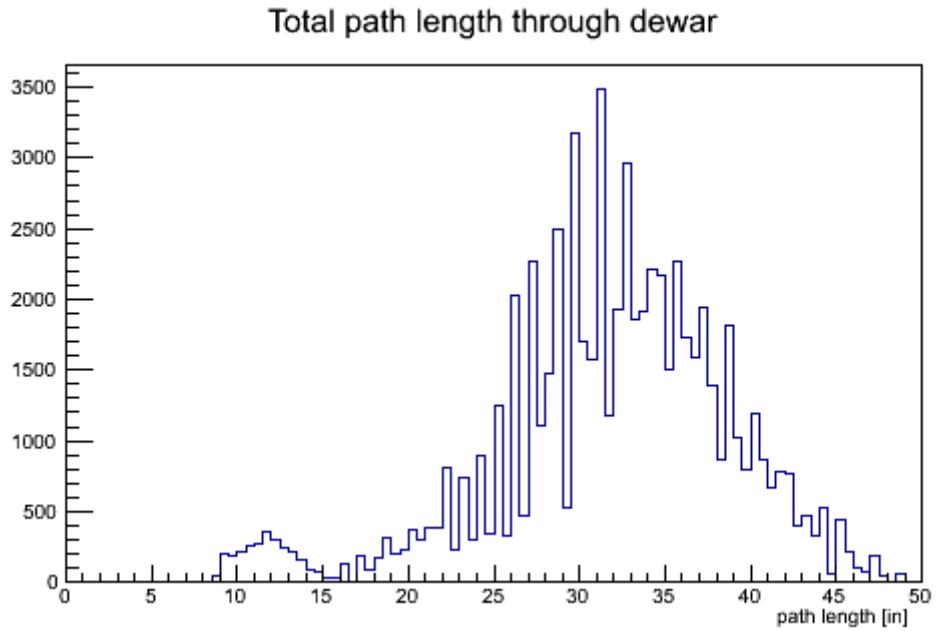
- Nevis shaper/amplifier
  - (gain ~ 200x)



- CAEN DT5740
  - 32 input channels
  - 62.5 MHz sample rate
    - (16 ns / sample)
  - 0.48 mV / ADC Count
    - (12-bit, 2 V pp input range)

- Reconstructed track parameters





- Ready to study light yields versus track parameters
  - Distance to bar
  - Angle w.r.t. bar
  - Path length through dewar